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EVALUATION OF SEVERAL EXPERIMENTAL AVIATION SELECTION TESTS

James R. Berkshire



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EVALUATION OF SEVERAL EXPERIMENTAL AVIATION SELECTION TESTS

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Bureau of Medicine and Surgery
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NAVAL AEROSPACE MEDICAL INSTITUTE
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SUMMARY PAGE

THE PROBLEM

The tests currently available for the selection of men to be trained as naval aviators leave room for improvement. This is a study to determine whether any of several experimental tests might add significantly to the validity of the present battery.

FINDINGS

A short-form of the Instrument Comprehension test and the more valid items of the Background test appear to merit revalidation under actual selection conditions. One or two of the scores from the Prestige/Security scale may add to the validity of secondary selection formulae, i.e. those used to estimate the probable success of students who are already in training.

INTRODUCTION

This report describes efforts to develop several new tests that might add to the validity of the battery used to select naval aviators. The current battery includes a general intelligence test, the Aviation Qualification Test (AQT), which, while mainly verbal-numerical, also contains some items that measure clerical accuracy. Scores on this test relate to performance in academic subjects, usually with correlations of about .60 in unrestricted samples. The balance of the battery includes two tests, the Mechanical Comprehension Test (MCT) and the Spatial Apperception Test (SAT), that discriminate between potential flight failures and successes, and a third test, the Biographical Inventory (BI), that has a useful predictive relationship to voluntary withdrawal from the flight training program. Scores from these latter three tests make up a composite "Flight Aptitude Rating" (FAR) which is expressed in stanine scores. In an unrestricted sample these scores usually have a correlation of .40 to .50 (biserial) with a dichotomous, completed/dropped criterion.

Figure 1 shows the relationship of the FAR battery scores to success in flight training. It can be seen that even in the two highest stanine groups, about 15 per cent of the selectees failed to complete the program. It was reasoned that if there were flight training failures among this 15 per cent, an examination of the causes of their failures might reveal areas of flying ability not now covered by the tests.

Twenty such persons were found, and the comments made about their flying by the flight instructors were examined. Two comments occurred sufficiently often to be provocative: The first described a persistent pattern of landing too high or too low, an apparent inability to judge the height of the plane in relation to the runway; the second dealt with the students being unable to proceed correctly through the sequence of actions required to complete a maneuver.

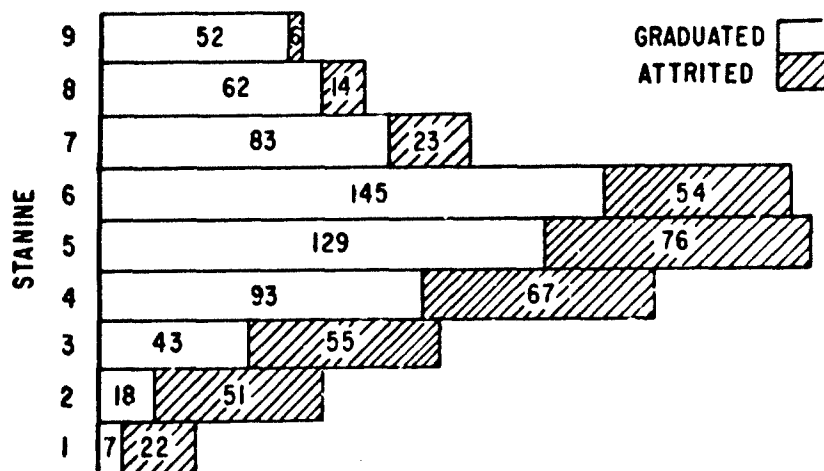


Figure 1

Relationship of FAR Scores to Success in Flight Training

EXPERIMENTAL TESTS

Two tests hopefully intended to measure these abilities were devised, "Altitude Judgment" and the "Maneuvers Test." For the Altitude Judgment test a large number of 35-mm photographs of the runway were taken through the windshield as a plane was coming in for a landing. They were taken at various points in the descent and with the plane in varying altitudes and positions relative to the landing strip. From the finished slides reproducible drawings were made by projecting the slides on a glass screen and tracing them on translucent paper. A selection of these was made for the test, a portion of which is shown in Appendix A.

The "Maneuvers Test" described the operating characteristics of a hypothetical, simplified airplane. It then asked the subject to specify the sequence of throttle, rpm, and stick positions necessary to complete a series of maneuvers. These included "take-off," "climbing turn," "figure eight," "Immelman," "power-on glide," "field entry," and "landing." The correct answer might require as many as twelve steps which had to be in correct sequence. While a trial run of this test indicated some validity, the test was too difficult and the original scoring methods were unsatisfactory for general use. Efforts are current to develop a more practical version of the test.

A third test was developed by choosing from the sixty-item Instrument Comprehension Test used in the selection of Air Force Pilots the twenty items with the largest correlations with total test score. A sample item is shown in Appendix B.

These three tests were given preliminary evaluations by administering them to a mixed input of aviation trainees and obtaining their point biserial correlations with a criterion of pass/fail in basic training. Table I shows the results. The obtained coefficients, while not very exciting, were significant at the .01 level and suggested further investigation.

Table I
Preliminary Evaluation of Three Experimental Tests

Test	No. Succeeded	No. Failed	Biserial
Altitude Judgment	480	78	.161
Maneuvers	310	37	.169
Instrument Comprehension	335	61	.140

Two other experimental tests were included in the evaluation covered by this report. One was called the "Background" test (1). This is a twenty-item scale used to estimate the cultural (or socioeconomic) level of the home at the time that the respondent was in high school. The remaining experimental measure is shown in Appendix C and derives from a scale originated by P. Nelson (2). The scale lists seventeen occupations as they were ranked in prestige, and then in security by aviation trainees. The subject is asked to place the naval aviator and the naval flight officer where he feels they belong in these rankings. Four scores were obtained; the Prestige and Security scores were the numbers of the levels at which the subject placed the naval aviator. The Prestige Difference and the Security Difference scores were the differences between the ranks that the subject assigned to aviators and to NFO's.

PROCEDURE

The experimental tests were administered to aviation students during their first week at Pensacola. Two years later the data were divided into the scores of those who completed training and of those who did not. The number of students was large enough also to permit division into Aviation Officer Candidates, who are college graduates, and civilian procured naval cadets, who normally have two years of college. Selection variables and a mathematics qualifying examination, also given during the first week, were included in the analysis.

RESULTS

The correlations of the variables with each other and with a complete/attrite criterion were computed. The Wherry-Doolittle procedure was used to identify the best combination of variables with which to predict attrition, and the appropriate weights were determined. Table II shows the results for AOC's during Pre-Flight training.

The Prestige Difference score and the Instrument Comprehension score were the second and third variables chosen. The Background and Security Difference scores also added to the multiple validity; however, the amounts they added were of little practical importance.

Table III shows the prediction formula for naval cadets during the same stage of training.

This formula differs somewhat from the formula for AOC's in that the Security Score replaced the Prestige Difference, and the SAT replaced the Instrument Comprehension Test.

Tables IV and V show comparable data taken at the end of Pre-Flight School and including Pre-Flight grades and ratings in the matrix.

Table II
Prediction Formula for AOC's* During Pre-Flight Training

Variable	Cumulative Shrunken R^{**}	Raw Score Weight
MCT	.2390	.016
Prestige Difference	.2854	.038
Instrument Comprehension	.2925	.010
BI	.2956	.003
Background	.2958	-.004
Security Difference	.2961	-.012

*N = 407

**R, point biserial

Variables not selected: Age, Education, AQT, SAT, Incoming Math, Altitude Judgment, Prestige Score, Security Score. (The matrices on which Tables II through V are based are shown in Appendix D.)

Table III
Prediction Formula for Cadets* During Pre-Flight Training

Variable	Cumulative Shrunken R	Raw Score Weight
MCT	.1802	.011
BI	.2331	.006
Security Score	.2576	.018
Age	.2721	-.002
Background	.2832	-.006
SAT	.2869	.006
AQT	.2935	-.003

*N = 379

Variables not selected: Education, Incoming Math, Altitude Judgment, Instrument Comprehension, Prestige Score, Prestige Difference, Security Difference.

Table IV
Prediction Formula for AOC's* at End of Pre-Flight Training

Variable	Cumulative Shrunken R	Raw Score Weight
Power Plants	.2353	.007
Peer Rating	.2844	.009
MCT	.3174	.013
Prestige Difference	.3539	.039
BI	.3560	.002
AQT	.3570	-.003
Instrument Comprehension	.3578	.007
Security Difference	.3587	-.012

*N = 405

Variables not selected: Age, Leadership, Navigation, Incoming Math, Prestige Score, Education, Physiology, Principles of Flight, Background, Security Score, SAT, Naval Orientation, Study Skills, Altitude Judgment.

Table V
Prediction Formula for NavCads* at End of Pre-Flight Training

Variable	Cumulative Shrunken R	Raw Score Weight
Power Plants	.2548	.005
Navigation	.2870	.008
BI	.3115	.005
Peer Rating	.3301	.006
Education	.3442	-.039
Background	.3539	-.006
Security Score	.3630	.014
Age	.3691	-.002
AQT	.3762	-.005
MCT	.3830	.006
Physiology	.3843	.003

*N = 377

Variables not selected: SAT, Principles of Flight, Altitude Judgment, Prestige Difference, Leadership, Study Skills, Instrument Comprehension, Security Difference, Naval Orientation, Incoming Math, Prestige Score.

DISCUSSION

First it should be noted that the multiple correlations shown in Tables II through V are from samples that have been severely restricted in range on the selection variables. This is so because individuals with low scores on the Flight Aptitude Rating and on the AQT were not accepted into the program. One effect of this is to limit the size of the correlations that can be obtained using these variables. But another is to increase the likelihood that other variables, not deliberately restricted by the selection process, will enter into the obtained multiple correlations. It cannot be assumed, therefore, that those experimental measures which add to the multiple correlations here would also add to them in the initial selection situation, where the variance of the present selection tests is still unrestricted.

Table VI shows which experimental tests contributed to each prediction formula. The Altitude Judgment test did not get into any of the four multiples. Thus it can be concluded that the validity shown for it in the preliminary study (Table I) duplicates variance that is present in other tests. From the intercorrelation matrices (Appendix D) it can be seen that these tests are probably the MCT and the Instrument Comprehension test.

Table VI
Contributions of Experimental Tests to Multiple Correlations

Experimental Test Variable	AOC During Pre-Flight	NavCad During Pre-Flight	AOC After Pre-Flight	NavCad After Pre-Flight
Altitude Judgment	--	--	--	--
Instrument Comprehension	✓	--	✓	--
Background	⊙	⊙*	--	⊙
Prestige Score	--	--	--	--
Prestige Difference	✓	--	✓	--
Security Score	--	✓	--	✓
Security Difference	⊙	--	⊙	--

*Checkmarks in circles indicate negative Beta weights.

The Instrument Comprehension Test entered into the formulae involving AOC's but not those involving NavCads. Given the low correlations and small increments with which we are dealing, this can probably be ascribed to chance. One should investigate this test further in the primary selection situation. The same can be said of the Background Test which added somewhat to three of the multiples. It exhibited negative Beta weights, higher socioeconomic level being associated with higher attrition rates. The more valid items from this test could very easily be added to the current Biographical Inventory and revalidated under selection conditions.

The Prestige/Security Scale presents a different case, however. Three of the four scores had some validity, but completion of the tests appears to require more knowledge of the pilot/NFO career options than men in the primary selection situation would be likely to have. Thus this test should probably best be given during test time that is available during the fifth week and the results validated when new secondary selection (student prediction) formulae are developed.

CONCLUSIONS

The short-form Instrument Comprehension test should be validated with the present selection battery.

The valid items from the Background Test should be incorporated into the Biographical Inventory and revalidated under selection conditions.

The Prestige/Security Scale should be administered during the fifth week of training and the scores included in the next developmental analysis for student prediction formulae.

REFERENCES

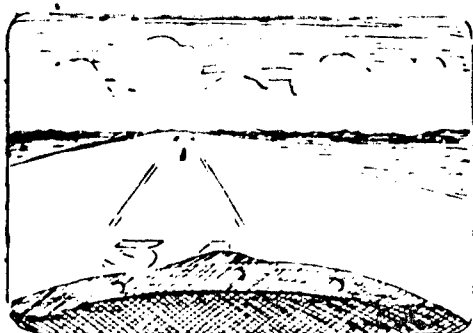
1. Berkshire, J. R., and Waters, L. K., A measure of cultural background.
NSAM-233. Pensacola, Fla.: Naval School of Aviation Medicine, 1959.
2. Nelson, P. D., A note on occupational ratings of security and prestige.
NSAM-325. Pensacola, Fla.: Naval School of Aviation Medicine, 1957.

APPENDIX A

Partial Instructions and Sample Items from the Altitude Judgment Test

This is a test of your ability to judge the altitude of an aircraft from the cockpit. The pictures used in the test are drawings made from photographs taken during actual landings. Four of the pictures are identified by the letters W, X, Y, Z. Twelve are numbered. You are to compare each of the lettered pictures with each of the numbered pictures.....

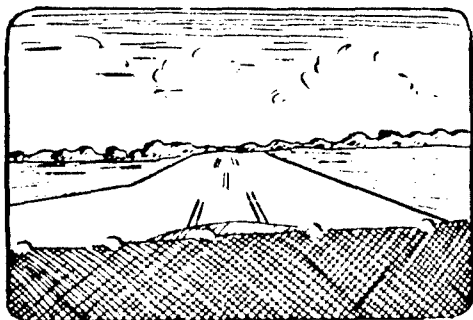
IF PLANE SEEMS HIGHER IN
LETTERED PICTURE - MARK A



W



X

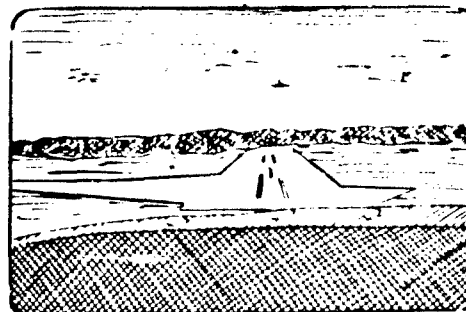


Y

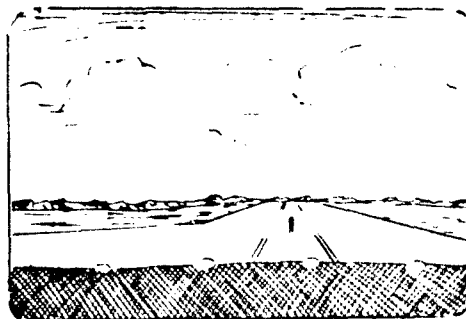
IF PLANE SEEMS HIGHER IN
NUMBERED PICTURE - MARK B



1



2



3

A-1

APPENDIX B

Partial Instructions for Instrument Comprehension Test

The compass indicates the direction in which the plane is headed. Note these sample readings:



HEADED NORTH



HEADED WEST



HEADED NORTHWEST



HEADED NORTH OF NW

The artificial horizon has two functions. First, it shows whether the plane is climbing, diving, or flying level. Second, it indicates the amount and direction of bank of the plane.

When climbing, the horizon lines appear below the small plane as in dial 1. When diving, the horizon lines appear above the small plane as in dial 2. When flying level, the horizon lines are even with the small plane.



1. CLIMBING



2. DIVING

The arrowhead in the dial registers the number of degrees of bank. A left bank is read in number of degrees to the right of zero as in dial 3. A right bank is read in number of degrees to the left of zero as in dial 4.



3. LEFT BANK



4. RIGHT BANK

When the plane is both banked and climbing, the dial appears as in dial 5. When the plane is both banked and diving, the dial appears as in dial 6.



5. LEFT BANK, CLIMBING



6. RIGHT BANK, DIVING

Now examine the dial readings in problem B. Then select the correct position of the plane.

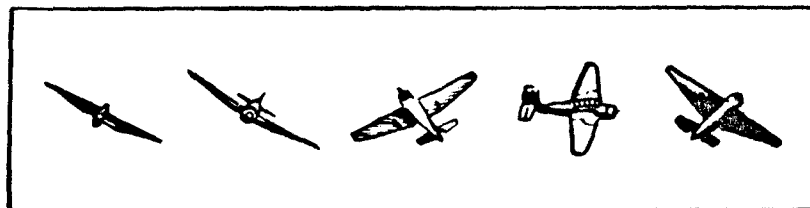
PROBLEM B



ARTIFICIAL HORIZON



COMPASS



A

B

C

D

E

According to the dials, the plane is banked left, flying level, and is headed south. (B) is the correct answer, because at position (B) the plane is banked left, flying level, and is headed south.

In each problem choose the position of the plane that is correct for the dial readings; then blacken the space on the answer sheet which corresponds to the answer you select. If you are not sure which is the correct answer, make the best guess you can. Work rapidly and carefully until you are told to stop. When you finish one page, go on to the next.

You will have 5 minutes to complete the 20 items. If you finish before time is called, you may go back over your work.

DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO.

APPENDIX C

NAME _____ CLASS NO. _____ DATE _____
 LAST FIRST MIDDLE
 AOC _____ N/C _____ M/C _____ AI _____ NAO _____ OI _____

The occupations below were ranked by 350 naval aviation trainees. Note that the left-hand list is ranked from top to bottom according to "PRESTIGE," while the right-hand list is ranked in terms of "CAREER SECURITY." Compare the prestige of the Naval or Marine Aviator with that of the occupations in the left-hand list and write in the letters NA at that point in the list where you feel the Naval or Marine Aviator fits. Do the same for the Naval Aviation Officer (non-pilot)-NAO. Then, in the right-hand list compare the NA and NAO career security with that of the occupations listed and write each into the appropriate space.

PRESTIGE

CAREER SECURITY

Physician	17	Physician
Scientist	16	Engineer
Minister	15	Scientist
Lawyer	14	Minister
Engineer	13	Banker
College Professor	12	College Professor
Banker	11	Lawyer
Architect	10	Architect
Politician	9	News Columnist
Businessman	8	Accountant
News Columnist	7	Businessman
Radio - TV Announcer	6	Personnel Director
Personnel Director	5	Farmer
Sales Promotion	4	High School Coach
High School Coach	3	Radio - TV Announcer
Accountant	2	Sales Promotion
Farmer	1	Politician

BOTTOM

BOTTOM

APPENDIX D

Intercorrelation Matrix -- AOC's* During Pre-Flight Training

	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015
Age															
Education	251														
AQT	019	043													
MCT	403	028	086												
SAT		019	028	086											
BI															
Mathematics															
Background															
Altitude Judgment															
Instrument Comprehension															
Prestige Score															
Prestige Difference															
Security Score															
Security Difference															
Complete/Attrite															

*N = 407. A coefficient of .115 is significant at the .01 level.

APPENDIX D

Intercorrelation Matrix -- Cadets* During Pre-Flight Training

	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015
Age	01	286	-058	019	051	059	-103	-015	090	098	-031	-059	055	020	-080
Education	02		124	-005	046	-022	085	027	021	058	-008	-030	-011	-005	-092
AQT	03			371	225	-099	480	048	161	164	-042	004	009	-018	-017
MCT	04				180	134	292	-063	244	242	-070	-016	006	024	187
SAT	05					000	083	020	230	266	025	063	017	-015	089
BI	06						-109	184	-032	208	041	-011	-001	044	179
Mathematics	07							-098	090	063	003	045	-006	-032	057
Background	08								021	055	-011	113	007	066	-068
Altitude Judgment	09									164	-068	-012	023	005	006
Instrument Comprehension	10										-013	145	022	096	092
Prestige Score	11											355	190	096	-009
Prestige Difference	12												016	267	-029
Security Score	13													452	121
Security Difference	14														063
Complete/Attrite	15														

*N = 379. A coefficient of .120 is significant at the .01 level.

APPENDIX D

Intercorrelation Matrix -- AOC's* After Pre-Flight Training

	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018	019	020	021	022	023
Age																							
Education	250	-048	C33	-026	099	-121	-010	-000	-096	012	-054	-010	036	-037	-008	087	072	024	-086	040	040	-006	
AQT	018	027	-060	-063	-106	034	003	-145	-013	-019	-099	007	075	020	090	046	-119	-096	021	003	-056		
IACT			000	172	009	297	182	418	260	350	430	419	348	544	059	199	274	-115	-089	-061	-139	074	
SAT				055	071	146	115	354	405	157	313	402	045	355	071	278	282	-063	-018	001	-092	237	
BI					-096	093	076	134	033	057	196	099	090	081	-045	181	332	-043	-024	-112	-037	000	
Leadership						-030	042	062	078	-071	-015	110	024	-034	110	033	142	159	070	016	053	101	
Peer Rating							100	340	267	410	270	355	248	114	030	061	113	-095	-049	-040	-078	061	
Physiology								194	225	205	313	253	152	212	017	060	163	-050	-088	-062	004	216	
Power Plants									409	395	398	496	202	287	-001	094	222	-036	-004	035	-097	168	
Naval Orientation										253	416	604	044	280	-076	060	158	-027	035	038	-074	240	
Principles of Flight											279	337	289	105	055	124	117	-124	-058	-078	-112	052	
Study Skills												539	178	462	-036	120	285	-090	-068	-030	-061	172	
Mathematics													124	380	-064	098	175	-102	-047	-041	-133	193	
Background														168	078	022	100	-067	-006	-077	-032	052	
Altitude Judgment															-054	072	213	004	030	006	-035	120	
Instrument Comprehension																096	050	-018	-018	-089	-037	-021	
Prestige Score																	299	-021	-059	-031	041	076	
Prestige Difference																		049	056	014	056	156	
Security Score																			341	315	111	030	
Security Difference																				071	330	133	
Complete/Attrite																					357	029	-009

*N = 405. A coefficient of .116 is significant at the .01 level.

APPENDIX D

Intercorrelation Matrix -- Coders' After Pre-Flight Training

	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018	019	020	021	022	023
Age																							
Education	287	-057	020	058	060	037	159	-083	-016	016	-028	-026	019	-104	-013	093	103	-035	-061	060	023	-076	
AQT	123	-005	042	-022	179	086	033	-029	131	062	048	141	086	026	020	055	-005	-029	-014	-007	-097		
MCT	373	223	-097	343	122	308	159	349	326	328	377	480	050	161	165	-040	006	008	-020	-022			
SAT	179	133	125	126	295	460	116	217	440	119	293	-065	242	240	-068	-016	003	022	186				
BI																							
Leadership																							
Peer Rating																							
Physiology																							
Power Plants																							
Navy Orientation																							
Navigation																							
Principles of Flight																							
Study Skills																							
Mathematics																							
Background																							
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Security Score																							
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